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Full Length Research Paper

Determination of the characteristics of plant exudates from selected tropical trees and unripe fruits

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Exudates were obtained from the African pear and mango trees and also from unripe plantain and banana fruit bunches, and their keeping and functional properties as industrial raw materials were determined. Exudation from the trees was carried out by making an incision on the tree bark, while those from the unripe fruit were collected from the cutting made to severe the bunch from the stock during harvesting. Results obtained showed a yield of 20.8 and 18.6 g/tree of African pear and mango respectively after 24 h of tapping and 8.6 and 10.2 ml/kg for plantain and banana per bunch, respectively. The yield of exudates from the plantain and banana trunks was 158.5 and 120.2 ml/tree, respectively. Other results were pH: African pear, 5.35; mango, 6.05; plantain, 4.93 and banana, 6.44; phenol contents: African pear, 15.67 mg/kg; mango, 15.97 mg/kg; plantain, 12.54 mg/kg and banana, 9.40 mg/kg; tannin content: African pear, 0.32%; mango, 0.28%; plantain, 0.32%, and banana, 0.46%. The exudates were soluble in polar solvent and sparingly soluble in organic and non polar solvents and all of them had a good amount of cations for cell growth present such as calcium, potassium, magnesium and sodium. They can also be preserved using well known food preservatives. From the results, it was deduced that the exudates may become raw materials for pharmaceutical and paint industries if the machinery for their collection and preservation are established.

Key words: Characterization, exudates, tropical trees, unripe fruits.

INTRODUCTION

Exudates are complex mixtures of organic compounds oozed by plants, often, but not always as a result of injury. These products are rich in carbon and hydrogen atoms and are also commonly called “sap” although the word “sap” is used to describe any fluid that travels inside plants. In contrast, the word “exudate” refers to any such material when it is oozed out of the plant (Santiago-Blay and Lambert, 2010)

These plant products have been collected since about 3000 BC, during the Egyptian civilization from Acacia and gum Arabic trees, native to North Africa and used as adhesive in hieroglyphic paints and in the embalming of Egyptian mummies. Nowadays, known exudates are employed as ingredients in medicines, cosmetics, perfumes, industrial and food products (Wolf, 2005; Hulse, 2006).

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In developing countries, plant exudates are used in traditional medicine, for example, a good percentage of the populations depend on medicines made from trees for their primary health-care needs ((Joy et al., 1998; FAO, 2004). *Commiphora caudata* used in Indian folk medicine as an antiulcerogenic agent was effective in the reduction of aspirin induced ulcer in albino rats and has also been used as anti bacterial and anti oxidation agent (Mothana et al., 2010; Nanthakumar et al., 2010). *Afzelia* gum was obtained from the bark exudates of *Afzelia africana* plant, characterized and evaluated for its compaction properties in hydrochlorothiazide tablet formulations. Formulations containing *Afzelia* gum as a binder show a slower onset and lower extent of plastic deformation than those containing the 2 standard binders, tragacanth and gelatin (Emeje et al., 2009). A number of plant gums/hydrocolloids have been used as binding, suspending or emulsifying agents in solid and liquid dosage formulations (Chukwu et al., 1994a, b; Nasipuri et al., 1996, 1997, 1999; Odeku, 1998, 2002, 2005; Emeje et al., 2007, 2008, 2009).

Figure 1. Cut surface of banana from where exudates ooze out for collection.

Figure 2. Chopped surface of plantain from where exudates flow out for collection.

Exudates are present in varying quantities in virtually all plants; however, the difficulties of collection can make such products to be industrially uneconomic. Commercially economic sources include: Tree bark, sap, leaves, fruits, seeds, roots, rhizomes of various woody and non-woody plants (Hulse, 2006). They are made accessible from trees and shrubs by tapping or incising the bark. When properly conducted, the tapping of such saps as latexes, gums, and resins does not disturb the forest canopy, kill the exploited tree, or remove its seeds from the site (Peters, 1999; Hulse, 2006). To promote the commercial use of exudates, UNIDO has developed a polyvalent pilot plant with a view to enabling developing countries to upgrade their technology for the processing of medicinal and aromatic plants. This plant incorporates all salient features of a low cost, efficient, small capacity factory, which can carry out solvent extraction, solvent percolation, and concentration of miscella, solvent recovery, steam distillation and oil separation in a simple plant (Silva, 1997).

African pear (*Dacryodes edulis*), mango (*Mangifera indica*), banana (*Musa sapientum*), and plantain (*Musa paradisiaca*), grow abundantly in Nigeria especially in the rain forest region of the country. Under steam distillation, the resin from African pear had been reported to yield a peppery essential oil rich in sabinene, beta-phellandrene and limonene. It is planted in Southern Nigeria, Cameroon and Democratic Republic of Congo for its nutritious fruit, which has high oil content (World Agroforestry Centre, 2006). African pear exudates has been refined by dissolution in zylene, filtration using glass wool and evaporation of zylene to produce a clear oil which was used as substitute to cedar oil for oil immersion in high resolution light microscopy (personal communication). Mango is a rich source of vitamins A, C, and D. Its inner bark is light brown and bitter. Whitish latex exudes from cut twigs and a resin from cuts in the trunk and the bark is the source of a yellowish-brown dye used as silk (World Agroforestry Centre, 2006). No study has yet been reported on banana and plantain exudates.

This research work is therefore aimed at studying the potentials of the exudates from the selected plants as industrial raw materials. It covers the tapping, collection and determination of the characteristics of plant exudates from African pear and mango trees, and also from unripe banana and plantain bunches following their harvest. The yield of exudates, their pH, stability to microbial attack, solubility in organic and polar solvents, concentration of cations such as magnesium, potassium, sodium and calcium, as well as their contents of phenolic compounds and tannins which are important for their use in medicine and as food additives are reported.

MATERIALS AND METHODS

Exudation

Exudates were collected from the growing tress of African pear (*D. edulis*) and mango (*M. indica*) in the University of Port Harcourt and freshly harvested fruits of the plantain (*Musa paradiscia)* and banana (*Musa sapientum)* of the Faulty of Agriculture, University of Port Harcourt (Figures 1 to 6). Though exudates were collected from both the fruit bunch and the trunk for plantain and banana, only samples from the fruit bunches were subjected for further tests

Figure 3. Stem of plantain or banana which is another good source of exudates but not used in this study.

Figure 4. Exudates from plantain collected in a dish.

because the tree trunk sap behaved almost like water. Exudates were obtained from the stems of the trees by making incision on the barks with a sharp knife (Stanley, UK) as shown in Figure 6. The pointed end of the knife was pushed tangentially into the stem so as to penetrate the bark and then pushed up to strip off a small length of the bark longitudinally from the wood. The incisions were left to bleed for 24 h before the half-dried gummy exudates were gently removed from the surface using a plastic spoon and stored in a wide mouth glass bottle until use.

Yield of exudate

The exudate yield for the tree was recorded as the weight of exudate collected from a cut in the bark for 24 h after the cut was made while the yield from the unripe fruit was the weight of exudate collected from a weighed bunch of the fruit till it stopped bleeding which took about 30 min on the average. The exudate from plantain and banana trunks was collected from the chopped trunk shown in Figure 3.

Microbial stability

One gram of freshly collected exudates from mango and African pear or one milliliter of fresh exudates from plantain and banana was aseptically placed in a sterile test tube and dosed with 0.1 ml each of 1% w/v solution of the following preservatives in water:

Figure 5. Oozing out of exudates from the bark of African pear.

Figure 6. Exudation of mango by incision with Stanley knife.

Benzoic acid, sodium benzoate, sorbic acid, potassium sorbate and methyl paraben. The microbial growth during a 24 h period was monitored by culturing the mixture on nutrient agar.

Sample preparation for solubility tests

The raw exudates were dried in sunlight for 2 to 3 days and kept for tests. When needed, the dry exudate was powdered with mortar and pestle.

Characterization of exudates

Determination of functional properties

pH Value: The pH meter (Hanna Instruments UK, model 3035) was first calibrated with buffers 4 and 7 solutions. The sample powder was thoroughly mixed and 1 g was dissolved in 100 ml of hot distilled water. The mixture was allowed to stand for about one hour at room temperature before the pH and temperature were recorded. The procedure was repeated for all the samples. For plantain and banana, pH was measured on the freshly collected exudate.

Solubility in polar and non polar solvent

1 g of thoroughly mixed sample was dissolved in each of the solvents; toluene, hexane, ether, carbon-tetrachloride, cold/ hot water. The solution was allowed to stand for 30 min and the solubility of the sample in the different solvents was determined qualitatively.

Determination of relevant chemical constituents

Some other tests were carried out to determine the chemical compositions and constituents of the samples that would affect their use in the industry. These tests include presence of cations such as calcium, magnesium, sodium and potassium; phenols and tannin content.

Cations: Cations were determined using Perkins Elmer Atomic Absorption Spectrophotometer (AAS) (Model 290B, Perkin-Elmer Co. Ltd. USA) which was suitably calibrated. The AAS measurements were carried out in accordance with the procedures described subsequently. 1.0 g each, of the samples were weighed into a 250 ml conical flask. Thereafter, 5 ml at 60% perchloric acid and 10 ml of nitric acid were added and the sample heated in an electro-thermal heater till the solution became clear and produced white fumes. The sample was removed from heating, allowed to cool, diluted to 25 ml with distilled water and then sent for AAS analysis.

Test for phenols: 0.1 g of each of the samples was dissolved in 100 ml of distilled water by gentle heating and this was filtered. 2.5 ml of the filtrate was then transferred into a 100 ml conical flask and 2.5 ml of distilled water added. The blank was also prepared by measuring 2.5 ml of distilled water into another 100 ml conical flask. Thereafter, the sample and blank were treated the same way. 5 ml of 0.1 M NaOH was added followed by 2.5 ml of iodine and 0.5 ml of concentrated HCl and the sample and blank titrated against sodium thiosulphate using starch as an indicator. Titration was stopped when the solution became colourless. The titre values of the blank and sample were noted and recorded.

Table 1. Exudate yield and pH values.

Parameter	African pear	Mango	Plantain	Banana
Exudate yield (Average for 3 trials)	20.8 g/day/tree	18.6 g/day/tree	8.2 ml/kg of fruit bunch and 158.5 ml/tree	10.6 ml/kg of fruit bunch and 120.2 ml/tree
pH of exudate	5.35	6.05	4.93	6.44

Table 2. Microbial stability (Total cell count of microorganisms).

Plant	Time (h)	Benzoic acid	Sodium benzoate	Sorbic acid	Potassium sorbate	Methyl paraben
	0	1.5×10^3	1.5×10^3	1.5×10^3	1.5×10^3	1.5×10^3
Mango	12	0	0	0	0	0
	24	0	0	0	0	0
	0	2.8×10^2	2.8×10^2	2.8×10^2	2.8×10^2	2.8×10^2
African pear	12	0	0	0	0	0
	24	0	0	0	0	0
	0	3.8×10^4	3.8×10^4	3.8×10^4	3.8×10^4	3.8×10^4
Plantain	12	0	0	0	0	0
	24	0	0	0	0	0
	0	3.8×10^3	3.8×10^3	3.8×10^3	3.8×10^3	3.8×10^3
Banana	12	0	0	0	0	0
	24	0	0	0	0	0

Concentration of phenols was obtained as follows:

Phenol (mg/L) = (Blank titre – sample titre) × 1.567 × 4 × 10

Test for tannins

0.1 g of the sample was weighed and transferred to a 250 ml conical flask. 100 ml of distilled water was added to the sample and boiled for 1 h. The solution obtained was diluted to 100 ml and filtered. 1.0 ml of the filtrate, 10 ml of freshly prepared 17% sodium carbonate and 2.5 ml of Folin Denis reagent were placed in a test tube and allowed to stand for 20 min for colour development. Thereafter, the absorbance/optical density was read at 520 nm using the GBO Cintra 6 uv spectrophotometer. Also, the standard tannic acid curve was prepared.

The formula used to obtain the percentage of tannin is as follows:

$$\%\ \text{tannin} = \frac{\text{T(mg)} \times \text{filtrate volume (ml)}}{10 \times \text{aliquot (ml)} \times \text{sample weight (g)}}$$

where T(mg) = mg tannic acid obtained from the standard curve.
All reagents used were of general purpose grade.

RESULTS AND DISCUSSION

Results are presented in Tables 1 to 5 and Figures 1 to 7.

African Pear

From the experimental result obtained, it was observed that the exudates from the pear tree have a pH value of 5.35 which is acidic and comparable to that of the gum Arabic which has its pH between 4.5 and 5.5.

Like other gums, it contains some useful cations such as magnesium, which is present at a composition of 2.375 mg/kg where as values of magnesium present in other consumable product ranges from 12 to 247 mg/kg. The highest value of magnesium is obtained from the cashew nut which, contains about 270 mg/kg. Calcium was also found to be present at 10.075 mg/kg. Also, potassium and sodium were present at a concentrations of 3.625 and 8.15 mg/kg, respectively.

Solubility test carried out proved that the exudate sample is soluble in hot water, toluene and ether but insoluble in cold water which is a similar attribute to the gum arabic and tragacanth. From physical observation, this pear sample has a strong pungent smell and does not degrade on exposure to air. This odour is another quality associated with most gums. The level of degradation is to the barest minimum which is due to the presence of phenols. Phenols are widely used as antioxidants and are reasonably stable throughout the

Table 3. Solubility in polar solvents

Solvent	African pear	Mango	Plantain	Banana
Cold water	Insoluble	Insoluble	Soluble	Soluble
Warm water	Soluble	Soluble	Soluble	Soluble
Ether	Soluble	Sparingly Soluble	Soluble	Soluble
Carbon tetrachloride	Sparing soluble	Soluble	Sparingly soluble	Sparingly soluble

Table 4. Solubility in non polar solvents.

Solvent	African pear	Mango	Plantain	Banana
Hexane	Insoluble	Insoluble	Insoluble	Insoluble
Toluene	Soluble	Soluble	Insoluble	Insoluble

Table 5. Functional chemical properties.

Parameter	African pear	Mango	Plantain	Banana
Tannin (%)	0.32	0.28	0.32	0.464
Phenol (mg/kg)	15.67	15.67	12.54	9.402

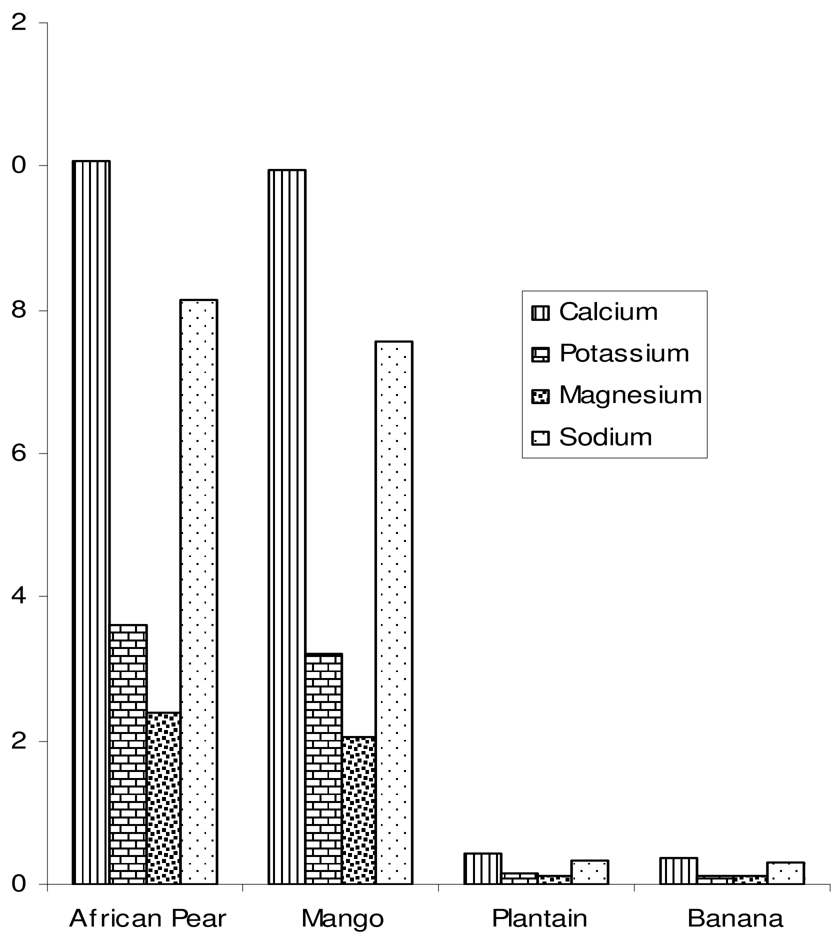

Figure 7. Cation (metal ions) contents of the exudates.

cooking and storage stage. Phenols impact little or no colour and have minimal taste. The amount of phenol determined was 15.67 mg/kg.

Furthermore, the amount of tannin present was determined to be 0.32%, which is not up to the range required for tannin and dyeing industries. With these limitations, this gum from the pear tree can only be recommended for use as antioxidants.

Mango

From the experimental results, the sample for mango had a pH of 6.05 which is acidic and above that of the pH range for gum arabic. Like other gums, it contains some useful cations in concentrations not in the range of consumable products. Solubility test carried out proved that this exudate is soluble in carbon-tetrachloride, toluene and hot water but insoluble in hexane, cold water and ether. The authors also observed that it has a strong, pungent smell and does not degrade easily on exposure to air. This is as a result of the presence of phenols, widely used as antioxidants. The amount of tannin present is also not in the range required for usefulness in tannin and dyeing industries. Like the African pear, it is going to be proper to use as an antioxidant.

Plantain and Banana

The exudates extracted from the unripe plantain and banana fruit peels were found to have a pH of 4.93 and 6.44, respectively, which is acidic and also comparable to that of gum arabic. They contain very low quantities of useful cations definitely not in the range for consumable products. They had aromatic smell which became pungent after a period of one week. The level of degradation was not very fast as a result of the presence of phenols, though not as much as the mango and pear exudates. As a result they could also be used as antioxidants.

Microbial stability

The tests on the efficacy of the usual food preservatives showed that all the food preservatives not only killed the organisms that got attached to the exudates during collection but stopped further growth or contamination by invading organisms. The test did not however cover growth of moulds.

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